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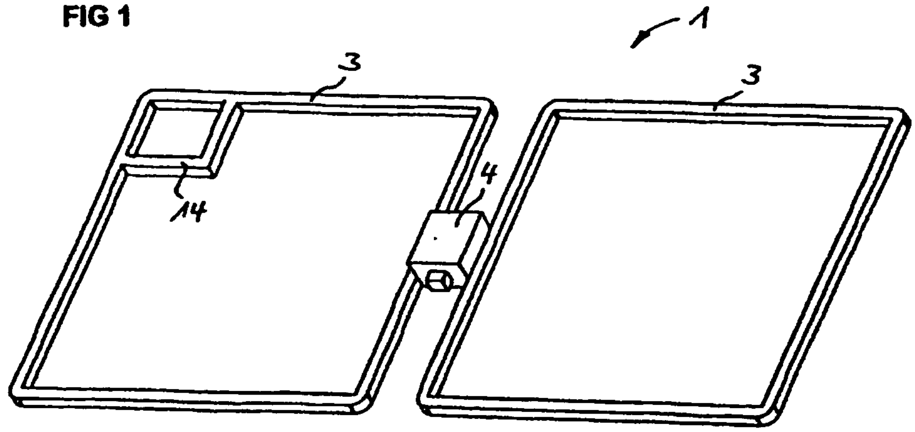
(54) **Antenna device for vehicle anti-theft system**

(57) An antenna device mounted in a vehicle comprising two individual antennae coils 3 communicates with a portable transponder in order to unlock the vehicle doors when a correct answer code signal is given by the transponder in response to a question code signal sent by the antennae. The coils are driven by sinusoidal signals from a control apparatus 4, the signals to one coil being phase displaced with respect to the other so that the resultant electromagnetic field moves to and fro in space. In this way the transponder can be detected regardless of its orientation with respect to the antennae. An individual antenna 3 may have a small energy coil 14 producing a high field density for charging a transponder energy store such as a capacitor, when it is in close proximity to the coil. The transponder may be in a key which is charged when inserted in a door lock. Th antennae may be placed in different parts of the vehicle such as in the doors, bumpers, floor, boot, or external mirrors.

FIG 1



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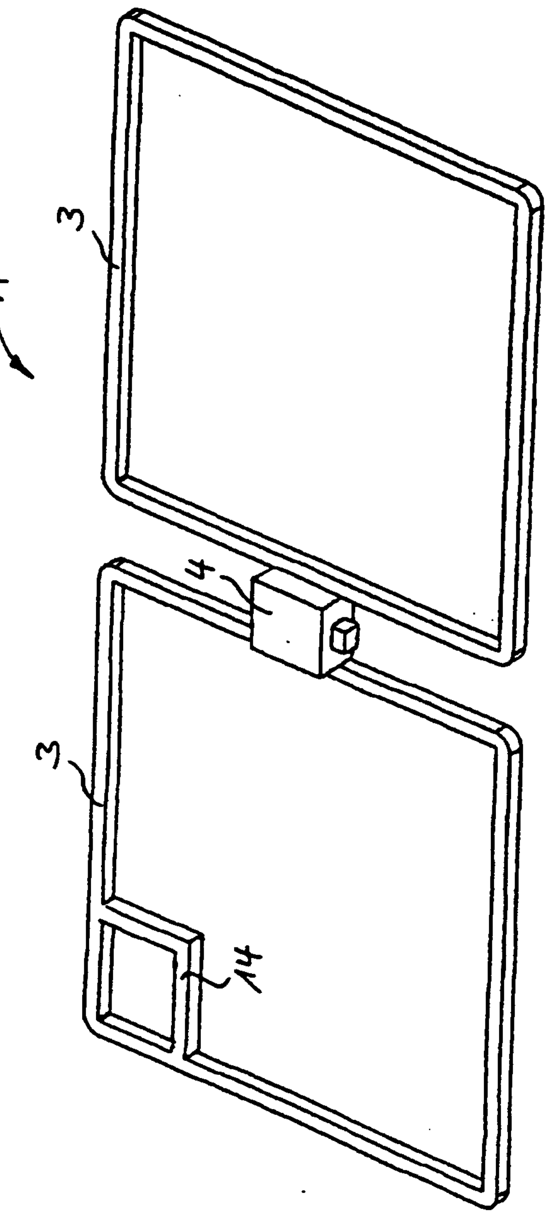


FIG 1

FIG 2

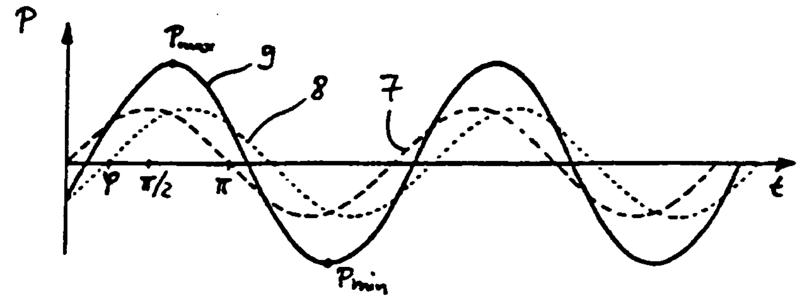


FIG 3

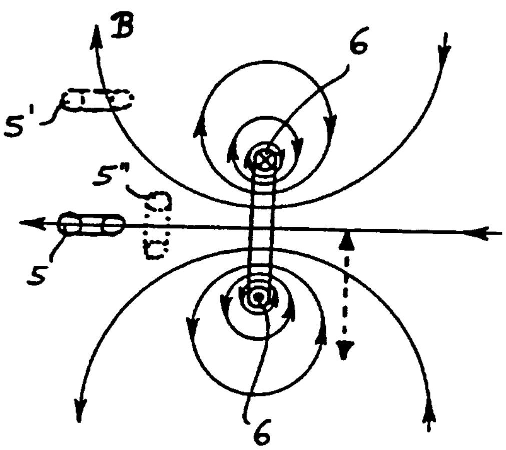
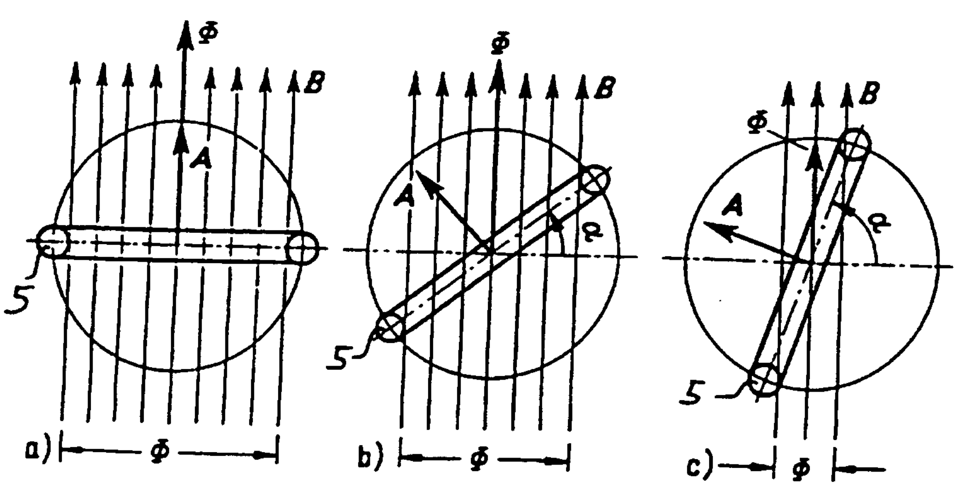


FIG 4



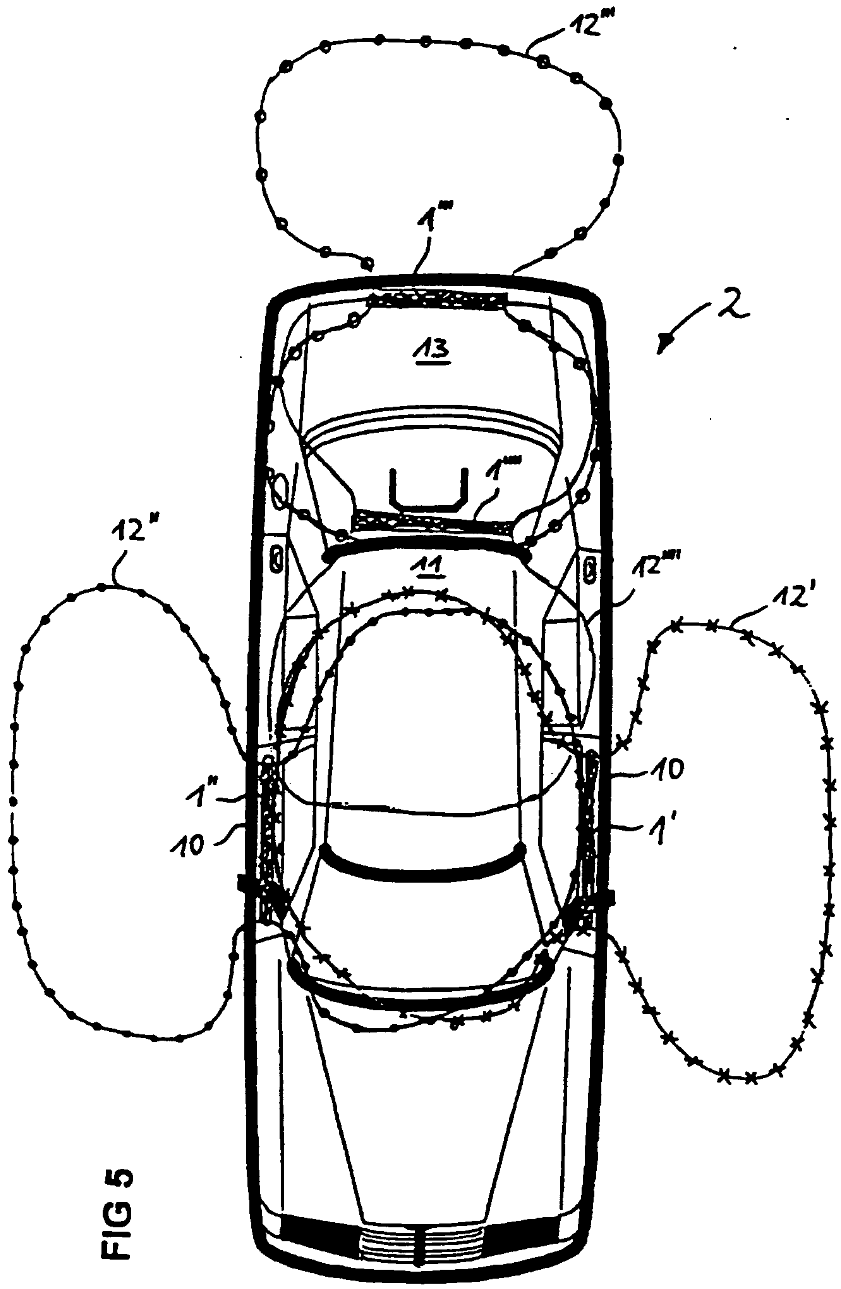


FIG 5

ANTENNA DEVICE

The invention relates to an antenna device, and in particular to an antenna device for an anti-theft system, which antenna device is arranged in a motor vehicle and by way of which signals are emitted to an identification unit and received thereby.

An antenna device known from DE 41 23 654 A1 is arranged in external mirrors of the motor vehicle. If a user wants to get into the vehicle, a question-answer dialogue is triggered by operating the door handle. In this connection, a question code signal is sent from an antenna to a transponder which is held by the user. This transponder sends back an answer code signal to the motor vehicle. The answer code signal is there compared with a desired code signal, and if the two agree the doors are unlocked.

Such antennae can be constructed as coils, as described in the printed publications DE 43 95 837 T1, DE 43 08 372 A1 or US 3,588,905, for example. By activating the coils with sinusoidal signals, electromagnetic fields are produced. These fields induce a voltage in a transponder coil of a portable transponder. In order that the induced voltage is as high as possible, field lines have to permeate the transponder coil to a sufficient degree.

It can, however, happen that the portable transponder is by chance positioned in such a way that the axis of the transponder coil is aligned at right angles to the axis of the coil in the motor vehicle. The transponder coil is then not permeated by the field, or is not permeated sufficiently, so that the question code signal is not received by the transponder.

For this reason, in a further antenna arrangement known from DE 41 05 826 A1, the coils are arranged at right angles to each other. A large amount of space is

required for this arrangement, however.

The present invention s eks to develop an antenna device with which both data signals and energy signals are reliably transmitted to a portable transponder if the transponder is in the vicinity of the antenna device.

According to the present invention, there is provided an antenna device for an anti-theft system, which antenna device comprises:

at least one pair of coils positioned adjacent to but spacially separated from each other and by means of which an electromagnetic field corresponding to an alternating question code signal may be emitted; and

control means for feeding said alternating question code signals to said pair of coils such that the signals are displaced in phase in one coil with respect to the other such that the effective electromagnetic field transmitted by the pair of coils moves to and fro in space.

For a better understanding of the present invention, and to show how it may be brought into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 shows an antenna device in accordance with the invention;

Figure 2 shows the superposition of sinusoidal waves;

Figure 3 shows a field pattern of the magnetic field produced by the antenna device;

Figures 4a to 4c show magnetic flux linkage of a coil in the magnetic field; and

Figure 5 shows a diagrammatic representation of the ranges of effectiveness of the magnetic fields in a motor vehicle.

As shown in Figure 1, an antenna device 1, in accordance with the invention, for an anti-theft system

is arranged on or in a motor vehicle 2. Said device consists of individual antennae 3, which are each activated by sinusoidal signals by way of a control apparatus 4. As a result of this, electromagnetic fields are produced, which fields are dependent on the geometric construction of the individual antennae 3 and on the power of the signals and superpose each other to form a superimposed field.

For an anti-theft system, first of all a question code signal is emitted, with the aid of the electromagnetic field of the antenna device 1, to a portable transponder. The transponder has a transponder coil 5 (see Figure 3) which receives the question code signal. An answer code signal is thereupon produced in the transponder, which answer code signal contains an item of user-specific code information. By way of the transponder coil 5 or another transmitter, the answer code signal is sent back to the individual antennae 3 or to another receiver in the motor vehicle 2. The answer code signal which is received is compared in the control apparatus 4 with a desired code signal, and if the two signals agree, a release signal, for example to unlock the doors or to release the immobiliser, is produced.

The question code signal can also be emitted partly simultaneously by a plurality of antenna devices 1′ to 1′′′′ (see Figure 5 in this respect) which are arranged in a manner such that they are distributed in or on the motor vehicle 2. Depending on which antenna device 1′ to 1′′′′ receives the signal, and the intensity with which the answer code signal is received, the transponder can be located. By means of the fact that the emission of the question code signal and the reception of the answer code signal are carried out in a manner such that they are successive with respect to time, and with the aid of the intensity

which is received, it is even possibl to recognise a direction of movement of the transponder.

The antenna device 1 in accordance with the invention consists of at least one pair of two individual antennae 3 which are spatially separated from each other. An individual antenna 3 consists in each case of a coil 6 having one or more turns, which are wound on a coil former.

Both individual antennae 3 are controlled separately from each other by way of the control apparatus 4. In this case, the two individual antennae 3 lie as close as possible to each other and are controlled, for example, with a phase displacement having a phase angle $\varphi = 45°$.

If a signal with a frequency of approximately 125 kHz is emitted by way of such an antenna device 1, both coils 6 produce electromagnetic fields (hereinafter referred to as magnetic fields) which superpose each other (hereinafter referred to as superimposed field).

The superposition of two sinusoidal magnetic fields is explained in a simplified manner in Figure 2 by means of the superposition of two sinusoidal signals 7 and 8. The second signal 8 (dotted curve in Figure 2) with which the second individual antenna 3 is controlled is phase-displaced with respect to the first signal 7 (dashed curve in Figure 2) with which the first individual antenna 3 is controlled by approximately the phase angle $\varphi = 45°$. As a superimposed field, a superimposed signal 9 with the same frequency is produced, but with the amplitude altered in dependence on the phase angle φ (the amplitude corresponds to the field strength).

The superposition of the signals 7 and 8 according to Figure 2 analogously applies for the superposition of magnetic fields produced by sinusoidal signals. The superposition according to Figure 2, however, applies

only for a single space point along the antenna device 1. At this space point, the field strength increases corresponding to the resulting superimposed signal 9 up to a maximum P_{max}, then decreases to a negative maximum P_{min} and increases again. This occurs later with respect to time in adjacent space points. A magnetic field in which the maximum P_{max} travels from one end, over the whole antenna device 1, to the other end and back again therefore results.

A field which moves to and fro is therefore produced, which field acts exactly as if an individual coil 6 were controlled with a single signal with the same frequency and the coil were moved to and fro in space (compare movement in accordance with the double arrow in Figure 3).

By altering the phase angle $\varphi = 45°$, varyingly high maxima can be achieved. The lowest maximum of the superposition field is reached if the phase angle $\varphi = 180°$. On the other hand, the highest maximum is reached if the phase angle $\varphi = 0°$.

A magnetic field B of an individual coil 6 is shown in Figure 3. As soon as the transponder with its transponder coil 5 is brought into this magnetic field B, the transponder coil 5 is permeated more or less strongly by the magnetic field B. This is dependent on the orientation of the transponder coil 5 and is explained in greater detail with the aid of Figures 4a to 4c.

If the transponder with its transponder coil 5 is in the magnetic field B (see Figures 4a to 4c), the size of the voltage induced in the transponder coil 5 (the linked flux Φ is proportional to said voltage) is dependent, among other things, on an angle α, which is the angle between the area of turn A (i.e. the area enclosed by the turn of the transponder coil 5; in Figure 4, area vectors A and flux-linkage vectors Φ are

shown) of the transponder coil 5 and the field lines of the magnetic field B produced by the individual antennae 3.

The induced voltage is highest if the transponder coil 5 is permeated at right angles to the magnetic field lines (Figure 4a), and is very low if said transponder is arranged substantially parallel to the magnetic field lines (Figure 4c). The level of the voltage is furthermore dependent on the active area of turn A that is enclosed by the turns of the transponder coil 5.

The dependency of the linked flux Φ on the angle α is explained by the generally known formula $\Phi = B \cdot A \cdot \cos\alpha$.

Corresponding to this, it can arise that no voltage, or only a very slight voltage, is induced in the transponder coil 5 if the transponder coil 5 is arranged in parallel with the field lines (in accordance with the continuous line in Figure 3 and approaching Figure 4c). This position is also termed spatial zero because no answer code signal comes back from the transponder.

If the coil 6 - in Figure 3 - is now moved downwards or upwards in accordance with the double arrow, field lines again sufficiently cut the transponder coil 5' (dashed line in Figure 3) so that in turn a comparatively high voltage is induced in the transponder coil 5. The induced voltage is highest if the turns of the transponder coil 5'' are arranged in parallel with the turns of the individual antennae 3 (dotted line in Figure 3).

The same effect as the displacement of the coils 6 of the antenna device 1 is achieved by the antenna device 1 if both individual antennae 3 are controlled with sinusoidal signals in a manner such that they are phase-displaced. In this way, a "virtual" antenna is

produced, which is moved to and fro. As a result of this, a situation is achieved in which the transponder coil 5 is penetrated many times by the field lines of the antenna device 1. The transponder then receives the question code signal and can consequently answer with its answer code signal as soon as it is arranged in the vicinity of the antenna device 1.

The orientation of the transponder coil 5 is more or less by chance and depends on how the user happens to carry the transponder with him. In this connection, the transponder can be arranged on a key or on a card the size of a credit card. The transponder can thus be carried in a jacket pocket or shirt/trouser pocket, or in a handbag.

The two coils 6 of the individual antennae 3 can be round, angular or even asymmetric. It is important that a pair of coils 6 are arranged so as to be directly adjacent to each other, so that their two magnetic fields can actively superpose each other and a superimposed field results. The two coils 6 can also partially overlap each other. As a result of this, a situation is achieved in which the amplitude of the superimposed field becomes stronger and, depending on the overlap, deviates more strongly from the sinusoidal shape.

The turns of each coil 6 can lie one above the other in a manner such that they are concentric and the same shape, so that the individual turns lie close together. Consequently, the coils 6 can be arranged in a narrow coil former. As a result of this a sharply delimited magnetic field is produced.

The turns can, however, also be arranged in the coil former in a manner such that they are spatially distributed or offset, so that the coil former has to be wider and as a result of this a spatially wider, asymmetrically distributed superimposed field is

produced. As a result of this, the probability of regions occurring, in the vicinity of the antenna device 1, in which only a slight magnetic field is present, is reduced. For this reason, the spatial zeros are not delimited so sharply. Apart from this, the maximum P_{max} of the superimposed field is made smaller. The intensity in the spatial zeros is made larger.

The precise geometric shape and the position of the coils 6 are dependent on the place of use and on the place of installation inside the motor vehicle 2 (see Figure 5). If signals are to be sent to a transponder in the interior of the motor vehicle 2, then at least one pair of individual antennae 3 is arranged in the inside lining of the doors 10, in the vehicle roof, under the seats 11 or in the vehicle floor (see Figure 5). Likewise, the shapes of the coils 6 and the phase displacement with the phase angle φ have to be coordinated. As a result of this, the magnetic fields which are produced can take on any desired three-dimensional shapes. The phase displacement can also be varied so as to be successive with respect to time, so that the magnetic field also reaches transponders at various distances from the motor vehicle 2.

A magnetic field which is active in a specified range (termed capture ranges 12′ to 12′′′′ in the following) is produced by each antenna device 1. The transponder has to be inside these capture ranges 12 in order to be able to send back an answer code signal.

If the capture ranges 12′ and 12′′ are outside the vehicle in the vicinity of the vehicle doors 10, then at least one pair of individual antennae 3 is arranged on the outside of the motor vehicle 2 in the doors 10, in the bumpers, in the vehicle floor or in the external mirrors.

At least one pair of individual antennae 3 can be arranged under the hat shelf, in the boot 13 or in the vicinity thereof, in order to emit signals to a transponder in the boot 13 or in direct proximity thereto. The capture range 12''' is then in or around the boot.

If the individual antenna 3 are arranged on the outside of the doors, then as a result of this the screening action of the sheet metal of the vehicle doors is exploited in order that the magnetic field towards the vehicle passengers is weakened. This has the advantage that the magnetic field towards the outside region can be emitted with maximum field strength and range and nevertheless reaches the interior of the vehicle.

The two individual antennae 3 are controlled separately from each other. Depending on the phase displacement, the maximum intensity of the superimposed field can be larger or smaller. This can be exploited in order to produce superimposed fields having different ranges.

An individual antenna 3 can be controlled with various signal shapes or capacities. Thus, for example, the individual antenna 3 can be operated with maximum capacity if the transponder is in the outside space. As a result of this, a maximum range of the question code signal is achieved. On the other hand, the individual antenna 3 is operated with reduced capacity if the transponder is in the interior of the motor vehicle 2. As a result of this, the electromagnetic load on the vehicle passengers is reduced. Apart from this, excessive ranges of the individual antennae 3 are avoided.

In accordance with an embodiment of the invention, an individual antenna 3 may have one or more comparatively small energy coils 14, arranged inside

the coil 6. Consequently, there is produced on a relatively small surface a magnetic field which has a higher field-line density in comparison with the magnetic field of solely the coil 6. Consequently, a local increase in the field strength is effected.

As a result of the energy transmission, an energy store, such as an accumulator or a capacitor for example, in the transponder can be charged if the transponder is in direct proximity to this energy coil 14. In order to achieve this, the transponder can be held in the vicinity of the energy coil 14. If the transponder is arranged on a key and the energy coil 14 is arranged in the vicinity of a door lock, the energy store may be automatically charged when the key is inserted into the lock.

Equally, there can be a recess in the motor vehicle, into which recess the transponder is placed in order to charge the energy store. As a result of the energy transmission, it is ensured that the transponder can at least emit the answer code signal if its energy store is empty (emergency operation).

The energy coil 14 can have one or more turns. It is advantageous if the turns all lie close to each other in order that the increase in the field strength is as great as possible. The energy coil 14 is connected to the coil 6 of the individual antenna 3 and is wound with the said coil 6 in one operation. As a result, both coils 6 and 14 are jointly controlled by the signals.

The frequencies of the signals are chosen in such a way that the ranges are optimised with regard to the materials used in the construction of the vehicle, such as steel, aluminium, plastics, etc. If, for example, metals are to be penetrated by the magnetic field (this is the case if an individual antenna 3 arranged on the outside of the motor vehicle 2 is also to radiate into

the interior), then low frequency fields are produced. As a r sult of this, disruptive eddy currents are also avoided.

The frequencies of the signals are chosen in such a way that the characteristics of the individual antennae 3 are used in an optimal manner. High frequencies having short wave lengths are produced if the signals are to be transmitted over large distances but are to be transmitted in a manner which is substantially irrespective of distance and direction. Low frequencies are chosen if only a small range of the superimposed field is required. As a result of this, reflections on distant metal surfaces are avoided or at least minimised. Likewise, undesirable excessive range of the magnetic field is avoided. Consequently, the danger of the question code signal being tapped without authorization is reduced.

The control of the individual antennae 3 by the sinusoidal signals can in this connection be set out in such a way that the question code signal always reliably reaches the assumed or possible "stopping region" (see Figure 5) of the transponder.

In the exemplary embodiment according to Figure 5, four antenna devices 1' to 1"", i.e. four pairs of individual antennae 3, are arranged in the motor vehicle 2. In this connection, the pairs produce magnetic fields, the capture ranges 12 of which are constructed according to the development of the individual antennae 3 and control by appropriate signals. In this connection, a common control apparatus (not represented) can send signals to each pair and receive signals from them. The signals can then be evaluated appropriately in the control apparatus.

CLAIMS

1. An antenna device for an anti-theft system, which antenna device comprises:

at least one pair of coils positioned adjacent to but spacially separated from each other and by means of which an electromagnetic field corresponding to an alternating question code signal may be emitted; and

control means for feeding said alternating question code signals to said pair of coils such that the signals are displaced in phase in one coil with respect to the other such that the effective electromagnetic field transmitted by the pair of coils moves to and fro in space.

2. An antenna device as claimed in claim 1, also having an energy coil arranged in the region of one of the coils, and wherein said control means is arranged to feed said energy coil with a comparatively high signal level in order that a localised increase in the field strength of the electromagnetic field is produced.

3. An antenna device as claimed in claim 2, wherein the coils are connected to each other and the energy coil is constructed in one piece together with one of the coils.

4. An antenna device according to claims 2 or 3, wherein the control means is aranged to feed the coils with signals of different level, and wherein the energy coil is fed jointly with one of the coils.

5. An antenna device according to one of claims 2 to 4, wherein a holder is arranged in the region of the energy coil, into which holder a transponder may be placed in order to charge an energy store of the transponder.

6. An antenna device as claimed in any preceding claim wherein all coils are arranged in approximately one plane.

7. An antenna device according to any preceding claim, the coils are constructed so as to be geometrically different, so that in the case of feeding the coils with sinusoidal signals, an asymmetrical electromagnetic field results.

8. An antenna device as claimed in any preceding claim for an anti-theft system, which antenna device is arranged in a motor vehicle and by way of which, said question code signal is emitted to a portable transponder, which upon receipt sends back an answer code signal by way of the antenna device to a control unit wherein the answer code signal is compared with a desired code signal and a release signal for said vehicle is produced if there is agreement between the code signals.

9. An antenna device according to claim 8, characterised in that it is arranged in the driver door, in the passenger door, in the vehicle roof and/or in the interior of the vehicle.

10. An antenna device substantially as herein described with reference to the accompanying drawings.

11. Antenna device for an anti-theft system, which antenna device is arranged in a motor vehicle and by way of which, controlled by a control apparatus, a question code signal is emitted to a portable transponder, which thereupon sends back an answer code signal by way of the antenna device to the control unit, where the answer code signal is compared with a desired code signal and a release signal is produced if there is agreement, characterised in that

- the antenna device has at least one pair of sending and receiving coils, which are spatially separated from each other, are arranged as close to each other as possible, and by way of which the question code signal is emitted and the answer code signal is received, and in that

- an energy coil is arranged in the region of one of the sending and receiving coils, which energy coil is controlled with a comparatively high capacity in order that a local increase in the field strength of the electromagnetic field is produced,

- with the sending and receiving coils being connected to each other and the energy coil being constructed in one piece together with one of the sending and receiving coils, and all coils being arranged in approximately one plane, and

- with one of the sending and receiving coils and the energy coil on the one hand and the other sending and receiving coils on the other hand being controlled in a manner such that they are dephased by a phase angle (φ) in order that an electromagnetic field which moves to and fro is produced.

12. A motor vehicle incorporating at least one antenna device in accordance with any preceding claim.

The Patent Office

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Application N :	GB 9623734.2	**Examiner:**	Gareth Griffiths
Claims searched:	All	**Date of search:**	28 January 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): E2A (ABC, ALV), H4L (LADA, LADX, LASS, LCAC, LCAX)

Int Cl (Ed.6): B60R 25/10, E05B 49/00, G08B 13/24,GO8C 17/00, 17/02, 17/04, H01Q 3/26, 3/30, 3/34

Other: Online Database: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	GB2180123 A (SENELCO)	
A	US5134392 (TAKEUCHI)	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
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